Making Statues Move

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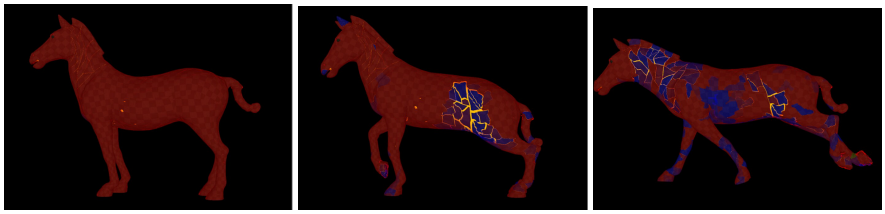

Figure 1: *Plate separation during movement. (Left image) The original horse. (Middle image) As the horse begins to move, the rear quarters are stretched, causing those plates to separate. (Right image) During a run, the plates that are near the stretched skin separates, while other plates that were previously stretched begin to heal. The yellow indicates a gap between the plates, red indicates plates that have not separated, while blue indicates fully separated plates.*

Exposition

A common story element in modern films is to have the statue of a creature made of stone or metal suddenly come to life and act like the animal or creature that the statue portrayed. One interpretation of such a visual effect is that the statue-creature retains the appearance of the statue material, while simultaneously moving in the life-like manner of the original creature, in contrast to having the statue completely transform into the living creature without having any statue-like characteristics. A simple way to accomplish such a visual effect is to rig a character normally with deformable skin, but use a material that emulates the statue's material in place of the usual skin or clothing material. This simple approach will fail to capture the visually expected effect that the rigidity of the the statue's shell material, such as stone, has on the statue-creature. A different approach is to simulate the cracking apart of the statue shell and retaining the remnants of that shell on the statue-creature during movement.

For *The Mummy: Tomb of the Dragon Emporer*, we have created the visual effect of a bronze statue of a horse coming to life, while retaining its statue-like appearance by retaining the look of cracked metal. Our technique can be replicated for any type of statue-to-creature transformation using many different materials. In addition, the effect can be reversed, yielding the visual effect of turning a living creature into a statue or having a creature be frozen or encased inside of a solid shell.

Techniques

Pipeline. Our approach utilizes a standard production pipeline. The crack patterns are first generated manually by a modeler. While it is possible to generate the crack patterns automatically, by allowing the artist to specify where the skin will crack gives better control over the final appearance of the visual effect. The horse rigs are then generated, and the animators then animate the horses according to the desired shot.

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Plate Formation. After animating the creature, the metal plates can be formed from the crack patterns by assuming that each piece moves rigidly along the surface of the skin. All vertices in a plate will then move in concert relative to the center of the plates by averaging the vertex positions. Our proprietary software will then determine when two plates will split apart by measuring the difference between the original and current areas of the plates. The rigidity of the plates can be controlled by interpolating between perfectly rigid plates (those that split apart upon any subtle movement) and perfectly elastic plates (those which stretch and deform based on any movement), shown in Figure 1. The plates are allowed to resume back to their original shapes based on a healing time.

2D Collisions. Once the plate behavior and elasticity has been determined, the plates can be visualized as moving independently along the surface of the model. These plates are then collided and bounced against each other along the surface of the horse. This is done by creating a simplified 2D collision model. The collisions are calculated by projecting each set of plates onto a two-dimensional plane orthogonal to the normal of the plate surface. The plates will then bounce based on the overlap in the direction along the surface of the plate. By using 2D collisions instead of 3D collisions, this process can be run at interactive speeds.

Metal Buckling. The plates need to appear to be made of metal, which will buckle and curl upon collisions. We created a deformation that emulates metal buckling by passing sine waves through the plate based on the amount of deformation and the direction of collision. The artist can control: how many waves are formed, the depth of the wave, and the upwards or downwards curling of the edges upon collision. Accurate models of metal buckling can be generated with finite element analysis. However, a simplified version that considers only the deformation of the mesh can be better controlled and tweaked by the artist.

Extensibility. The procedure for creating cracks on a skinned rig can be modified to accommodate other types of materials. For example, cracks made of clay can be produced by using the same plate formation and 2D collision, but reacting to collisions by crumbling, rather than by buckling.